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FURTHER STUDIES WITH THE MUSCADINE GRAPE

E. F. SAVAGE, *et al.*

Bulletins of this Station are sent free to residents of Georgia

H. P. STUCKEY, *Director*
EXPERIMENT, GEORGIA

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FURTHER STUDIES WITH THE MUSCADINE GRAPE

By E. F. SAVAGE, *et al.**

The material presented in this bulletin is intended as a release of experimental work with muscadine grapes to be of help to growers, processors, and research men working with this fruit. Commercial vineyards varying in size are being established in Georgia from year to year. Most of these contain some of the varieties originated by the Georgia Experiment Station. The fruit is sold to wineries, used for making unfermented juice, and for many other culinary purposes as well as to supply fresh fruit to the home and local markets. Muscadine grapes are adapted to both the Coastal Plain and Piedmont sections of Georgia and serve well as an additional cash crop on many farms of these two sections.

BOTANICAL DIFFERENCES

Vitis rotundifolia, the muscadine grape, differs so widely botanically from the other species of Vitis that some writers (12, 26) place it in a separate grouping. This distinctive grouping has become so well known in the southern states that to the grower, there are two classes of grapes, the muscadine or "Scuppernong" and the so-called "bunch grapes." Only those botanical differences which appear to be most important will be included in this report. For the sake of simplicity, most comparisons will be made between *Vitis rotundifolia* and *Vitis labrusca* as represented by the variety, Concord.

STEM. The wood of *Vitis rotundifolia* is very hard and compact with a specific gravity, according to the work of Williams (28), greater than that of water. *Vitis labrusca*, the species to which belong the greater number of eastern grape varieties, has a specific gravity less than water. The amount of pith in *Vitis rotundifolia* is quite small compared with other species with the xylem or wood forming the greater part of the stem. There is no diaphram present as in other species, although there is a tendency for the pith to become somewhat wider at the node. The bark of the rotundifolia grapes is very persistent, especially with younger vines. The bark of old vines tends to check off while that of the labrusca sheds off in long strips. Very prominent lenticels are present on the bark of the rotundifolia species, while absent in the labrusca. Large numbers of dichotomous aerial roots form on the older muscadine vines, both the wild and cultivated forms. Such aerial roots are not known in the ordinary varieties of the labrusca species. The tendrils of the labrusca group are branched and continuous, that is, there is either a tendril or flower cluster at each node. In the rotundifolia, with some variations, the tendrils are simple and discontinuous with every third node being devoid of either tendril or flower cluster.

LEAVES. The leaves of *Vitis rotundifolia* are much smaller and more nearly glabrous than *Vitis labrusca*. About the only pubescence to be found is on the under side of the leaves along the veins. The under side of the leaves of most varieties of labrusca are so highly pubescent as to be called tomentose.

FLOWERS. For all practical purposes the muscadine grape is dioecious and requires the presence of the staminate plant for the production of fruit. The blossom of the fruiting vine has a well-developed pistil, which resembles a minature milk bottle standing up in the center of the flower.

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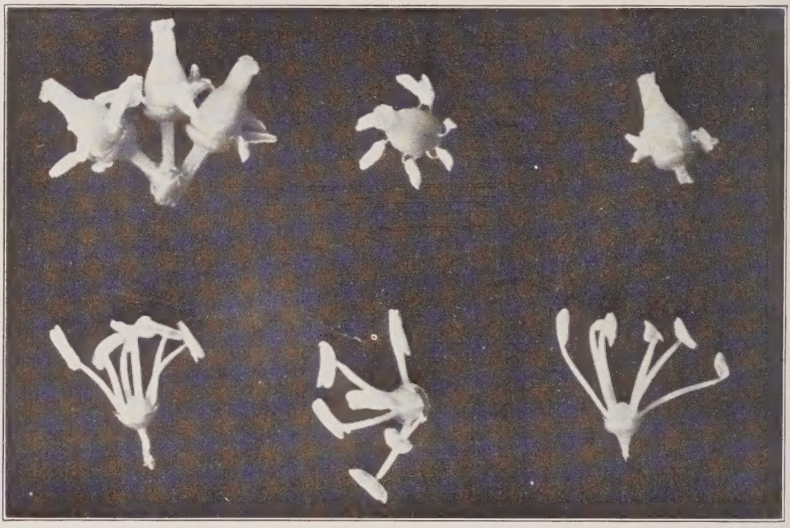

FIG. 1. *Blossoms of muscadine grape. Upper: female (pistillate) flowers, lower: male (staminate) flowers. (Mag. 5X).*

The stamens are generally short and recurved. Although pollen is produced on these pistillate blossoms, it does not seem to function. According to the work of Stuckey (27), and Reimer and Detzen (24), the pollen grain appears to be a mere shell incapable of germination. The staminate, or so-called male flower produces long, upright stamens with the pistil reduced to a mere functionless raised cushion with comparatively large clusters of blossoms whose erect stamens bear an abundance of pollen. The difference in the pistillate and staminate flowers is clearly depicted in figure 1.

This requirement of staminate plants for pollination and fruit production is strikingly different from the labrusca species. Cross pollination in muscadines is rare. On the other hand, most varieties of labrusca grapes are self-fertile, and those varieties which have reflexed stamens and are classified as self-sterile due to abortive pollen (11), may be cross pollinated with pollen from self-fertile varieties.

FRUIT. The fruit clusters of the muscadine group are small with the berries in many varieties tending to shell or fall from the cluster when ripe. The fruit is very characteristic with a thick, leathery appearing skin marked with small, russet dots in most varieties. The individual berries are large and round. The pulp is quite tough, but this toughness is not localized around the seeds as with the labrusca. The fruit has a characteristic musky odor and in many varieties tends to ripen unevenly in the cluster.

In contrast, the fruit cluster of labrusca varieties are larger and usually tapering with the berries ripening evenly and strongly holding to the cluster. The berries are usually covered with a waxy secretion known as "bloom," while with the rotundifolia grapes this bloom is not present. Both of these species of grapes may be classified as slipskins, that is, the skin is not adherent to the flesh.

CHEMICAL COMPARISONS OF THE FRUIT

A comparison of the expressed juices from the muscadine grape (3, 19) and the Concord grape (8), as representative of the labrusca species

over a four and five-year period respectively, indicates several chemical differences.

TOTAL SOLIDS. In these tests the Concord juice contained about 16.8 per cent total solids, while the muscadine juices ranged from 11.4 to 24.3 per cent. Some muscadine varieties showed a large variation over the four-year period; Brownie varied from 18.0 to 24.3 per cent; Dulcet ranged from 16.3 to 20.0 per cent; while other varieties showed very little variation with, for example, Stuckey varying only from a yearly average of 16.4 to 16.7 per cent over the four-year period. Approximately 90 per cent of the total solids in muscadine juices were sugars.

SUGARS. Practically all the sugars found in the Concord were reducing sugars, while in the muscadine varieties, such as the Hunt, Stuckey, and Dulcet, a large proportion of the sugar was sucrose. The Stuckey juice had a total sugar content of 14.64 per cent, of which 6.10 per cent was sucrose and 8.54 per cent was reducing sugars. Concord juice contained 14.38 per cent total sugars, of which 0.19 per cent was sucrose and 14.19 per cent reducing sugars. The figures given for the Stuckey juice are a four-year average, while those for the Concord juice is for a five-year average. Glucose, the predominant sugar in Concord grapes, has a relative sweetness of 74.3 to 100 for sucrose. Since these muscadine grapes have sucrose present, they should and do taste much sweeter than such labrusca grapes as the Concord that have the same amount of sugar but principally in the form of glucose.

TITRATABLE ACIDITY. In general, the Concord juice (grapes grown at Vineland, New Jersey) had considerably more titratable acidity than the muscadine juices (grapes grown at Experiment, Georgia). Over a five-year period the Concord juice varied from 102 to 157 cc. O.1 N. NaOH to neutralize 100 cc. of juice, while muscadine juices varied from 34 cc. for one sample of Dulcet to 141 cc. for Flowers. Seasonal variation was pronounced in some varieties of muscadines. One year Flowers juice had an average titratable acidity of 62 cc.; another year it had 141 cc. Most varieties did not vary as much from one season to another as the Flowers juice; the minimum for Qualitas juice was 66 cc. compared to a maximum of 85 cc.

NON-VOLATILE ORGANIC ACIDS. Nelson (20) identified l-malic acid and d-tartaric acid in the Concord grape. Of the non-volatile organic acids, l-malic acid accounted for about 60 per cent and d-tartaric acid about 40 per cent of the total present. In this variety, Hartman and Hillig (13) found a small amount of citric acid, 0.04 per cent. Alwood et al. (1) found 0.88 per cent tartaric acid in immature Concord grapes and 0.56 per cent tartaric in wine-ripe Concord grapes. In addition to malic and tartaric acids, Heiduschka and Pyriki (14) found that unripe vinifera grapes contain 0.004 to 0.019 per cent citric acid. During ripening the citric acid remains almost constant, although total titratable acidity greatly decreases.

Five varieties of ripe muscadine grapes (7) were found to contain from 0.71 to 1.14 per cent l-tartaric acid. An immature sample of the Hunt variety was found to contain 1.48 per cent of tartaric acid and 0.021 per cent of citric acid. A well-ripened sample of the same variety contained 1.04 per cent tartaric acid and 0.021 per cent citric acid. The tartaric acid evidently decreases during the ripening process, while the amount of citric acid remains constant. A sample of ripe Thomas grapes was found to contain 0.036 per cent of citric acid. No malic acid was found in muscadine grapes. This is a marked distinction between this species and the labrusca and vinifera.

TANNINS. Analyses on muscadine juices for one season only showed that they were considerably lower in tannin than were Concord juices taken over a three-year period. The muscadine juices varied from 21 mg. per liter tannin for Qualitas to 417 mg. for an unnamed seedling, while Concord juice varied from 397 mg. to 872 mg. with an average of 570 mg. of tannin per liter. When muscadine grapes were crushed and the

juices allowed to remain in contact with the skins and pulp, the resulting juice upon pressing was as high or higher in tannin than the Concord juice, depending upon the length of time between the crushing and the pressing of the grapes. This fact is of great importance to the processor.

ANTHOCYANIN PIGMENT. The anthocyanin pigment of blue vinifera grapes has been found to be oenin, a dimethoxydelphinidin monoglucoside (29, 30). Anderson (2) found the Concord grape to contain oenin also, but the Concord pigment appears to contain a larger amount of delphinidin monoglucoside than is present in the vinifera grape pigment.

In a study of the pigment of the Hunt variety of muscadine grapes (6) the anthocyanin was found to be quite distinct from that present in Concord, a representative blue variety of the labrusca species, and the blue vinifera grapes. The Hunt anthocyanin is muscadinin, a monomethoxydelphinidin diglucoside.

GRAPE SEED OIL. Upon comparing the quantity and characteristics of the oils from muscadine (21) and Concord seeds (22) very little appreciable differences were found. The average yield of oil from Concord seeds was about 13 per cent compared to an average of 12.9 per cent for six leading muscadine varieties. The minimum was 12.4 per cent for Creek and Yuga with a maximum of 13.6 per cent for Stuckey. Muscadine seeds are larger than Concord seeds, although there is a smaller number per berry in the muscadines. The iodine numbers, 134.1 for Concord oil and 130.5 for muscadine oil, along with many other physical and chemical characteristics, were in very close agreement. Probably the muscadine and the Concord grape seed oils can be used interchangeably for many commercial uses.

LOCATING THE VINEYARD

The muscadine grape requires a long growing season of 225-230 days. This length growing season is found in most sections of Georgia with the exception of the north Georgia mountain area. Muscadine grapes are not recommended for this section since they will not be as satisfactory as the so-called "bunch grapes." The life of the muscadine grape in middle and south Georgia ranges upward from 50 years. There are vines which are reportedly from 140 to 300 years old, while under ordinary circumstances such "bunch grapes" as the Concord and Niagara seldom last longer than six to eight years in the sections south of the mountain area of northern Georgia. It is for this reason primarily that muscadine grapes are to be preferred over the bunch grape varieties for the lower South.

The muscadine grape blooms in late May and early June, and thus the blossoms escape injury from spring frosts. Because of this late blooming, it might be expected that the grape is less subject to cold injury than other fruits. Occasionally, new shoots may be damaged by frost before the blossoms open, but of greater hazard to the muscadine grower are the severe cold waves occurring in midwinter. Selection of a site in which air drainage is good is an important factor since a variation of one to two degrees F. near the critical temperature may mean the difference between success and failure in growing this fruit. Figure 2 shows injury to a vine resulting from a temperature of 18° F. occurring on November 16, 1940.

FIG. 2. *Winter injury on three-year-old muscadine vine resulting from a temperature of 18° F. occurring in November*

In choosing a site for adequate air drainage, a slope so steep that erosion will be a serious problem should not be selected. In much of the rolling Piedmont country where the slopes are fairly steep, terraces or some other method will be necessary for erosion control. This increases production costs, and so far as possible, such adverse conditions should be avoided by the selection of a good site rather than attempting expensive remedial measures.

SOILS

Most of the better soils of the state are adapted to muscadine grape production. Good water drainage is essential in a vineyard and this is particularly true with the muscadine grapes. This species of grapes is quite resistant to drought but is intolerant of wet soils. During prolonged rainy periods it has been observed that the leaves are injured, developing dead areas along the veins. In extreme cases this results in a dropping of the leaves.

It is entirely probable that this plant has a higher oxygen requirement for best root development than most species. Any soil which is well drained with a moderate degree of fertility seems to be adapted to the growth of muscadines. Studies have shown that a 20-year-old vine on a Cecil clay loam soil had roots extending 36 feet from the main trunk. The roots of this vine grew near the surface except where cut and forced deeper by cultivation. This evidence again points to the fact that this plant prefers a well-aerated soil.

VARIETIES

During the last 25 years the Georgia Experiment Station has developed and introduced 13 varieties of muscadine grapes that are superior in one or more respects to the older varieties. Some of these Station introductions, as well as some of the better, older varieties, are shown in figure 3. Many of these are especially good for the home grower who wants a succession of varieties. These varieties planted in the home vineyard are capable of supplying fruit from the 20th of August until frost.

For the commercial grower interested in the production of grapes for wine and unfermented juice, there are several varieties which offer great promise. Among these are the Hunt, Yuga,

FIG. 3. *Some of the varieties introduced by the Georgia Experiment Station. Scuppernong and Thomas are not Station introductions but represent two of the better, older varieties.*

and Creek. The Hunt and Yuga are in good demand for planting in commercial vineyards, and the Creek introduced in 1938 will gain in popularity as soon as its high production and qualities as a wine grape are recognized.

HUNT. Clusters medium to large, black, skin medium, persistence good, quality excellent, ripens early, highly productive. Considered the best all-purpose dark variety.

YUGA. A seedling of Sanmonta; clusters large; berries medium; a clear, light-bronze color; skin thin; persistence very good; quality excellent; ripens late. It ripens over a long period and is excellent for home use as well as for wine.

CREEK. A seedling of Sanmonta, large clusters, medium berries, reddish-purple color, skin very thin, persistence fair, quality good to excellent, highly productive, an annual bearer, ripens late. Shows great possibilities as a wine grape because of its high production and characteristic bouquet.

Other varieties of muscadines are described in table 1 according to the size of clusters, size of fruit, color, skin, persistence, quality, relative time of ripening, and average harvesting date. The varieties are listed in four groups: older varieties, Munson's introductions, Georgia Experiment Station's introductions, and unnamed seedlings.

The color of the fruit ranges from greenish-bronze to dark amber in the light-colored varieties, and from reddish-purple to black in the dark-colored varieties. They are usually referred to as white or black. Persistence is the property of the berry adhering to the pedicel and is rated as good, fair, or poor. Quality refers to its dessert value. It is closely correlated with the sugar-acid ratio. Ripening dates may vary several days from year to year, but under similar conditions the varieties will retain their order of ripening.

POLLINATION

As has been previously discussed, muscadine grape vines are dioecious, that is, certain plants, the male vines, bear only staminate blossoms, and certain others which bear the pistillate flowers are the female or bearing vines. It has been repeatedly proved by the work of Stuckey and other (24, 27) that these plants are self-sterile and require male plants nearby for pollination.

Of the insects effecting pollination, Detzen (10) found that sweat bees are the most important and probably chiefly responsible for the cross pollination of all varieties. The honey bees do not seem to be attracted by the flowers of the grape and are not regarded of great importance in cross pollination.

PLANTING PLAN

In the work to date a ratio of one male vine to each eight to ten bearing vines has given very good results. Figure 4 shows the location of the male vines in a planting. The heavy, broken

TABLE 1
DESCRIPTION OF VARIETIES

VARIETY	CLUSTER	SIZE	COLOR	SKIN	PERSISTENCE	QUALITY	RELATIVE TIME OF RIPENING	AVERAGE HARVESTING DATE
(*Older*)								
Flowers	medium	med.-small	purplish-black	thick	good	poor	late	Oct. 2
James	medium	large	purplish-black	thick	good	fair	mid-season	Sept. 17
Memory	small	large	black	thick	fair	fair	mid-season	Sept. 18
Mish	medium	medium	purplish-black	med.-thin	fair	good	late mid-season	Sept. 21
Scuppernong	small	med.-large	bronze	med.-thick	poor	good	early	Sept. 11
Thomas	medium	med.-small	reddish-purple	medium	poor	good	early mid-season	Sept. 14
(*Munson Introd.*)								
Labama	med.-large	med.-small	black	medium	fair	fair	early mid-season	Sept. 14
LaSalle	medium	medium	black	med.-thin	poor	good	very early	Sept. 1
San Jacinto	large	med.-small	black	medium	fair	fair	mid-season	Sept. 15
Sanmonta	med.-large	small	black	medium	good	good	late	Sept. 30
Sanrubra	medium	small	reddish-amber	med.-thin	good	good	early	Sept. 8
(*Station Introd.*)								
Brownie	medium	small	dark amber	thin	good	excellent	late mid-season	Sept. 25
Creek	large	med.-small	reddish-purple	very thin	fair	good	late	Oct. 1
Dawn	small	large	bronze	thick	fair	good	very early	Aug. 26
Dulcet	medium	medium	reddish-purple	medium	very good	good	mid-season	Sept. 16
Howard	medium	med.-large	bronze	thick	fair	good	mid-season	Sept. 15
Hunt	large	med.-large	black	medium	good	excellent	early	Sept. 10
Irene	small	large	purplish-black	medium	fair	fair	mid-season	Sept. 18
Lucida	small	very large	greenish bronze	thick	good	fair	mid-season	Sept. 20
November	small	medium	bronze	med.-thick	good	good	late	Oct. 1
Qualitas	small	medium	purplish-black	medium	fair	fair	early mid-season	Sept. 13
Spalding	large	medium	black	medium	very good	good	late mid-season	Sept. 23
Stuckey	small	large	russet-bronze	thick	poor	excellent	mid-season	Sept. 20
Yuga	large	medium	light bronze	thin	very good	excellent	late	Sept. 29
(*Unnamed*)								
10–8	small	medium	bronze	medium	good	good	late mid-season	Sept. 23
10–38	small	med.-large	black	medium	good	good	late mid-season	Sept. 23
16–24	small	med.-large	black	medium	good	good	early	Sept. 12
18–20	medium	medium	bronze	medium	good	good	late	Sept. 28
21–36	small	med.-large	bronze	thick	fair	good	early	Sept. 12

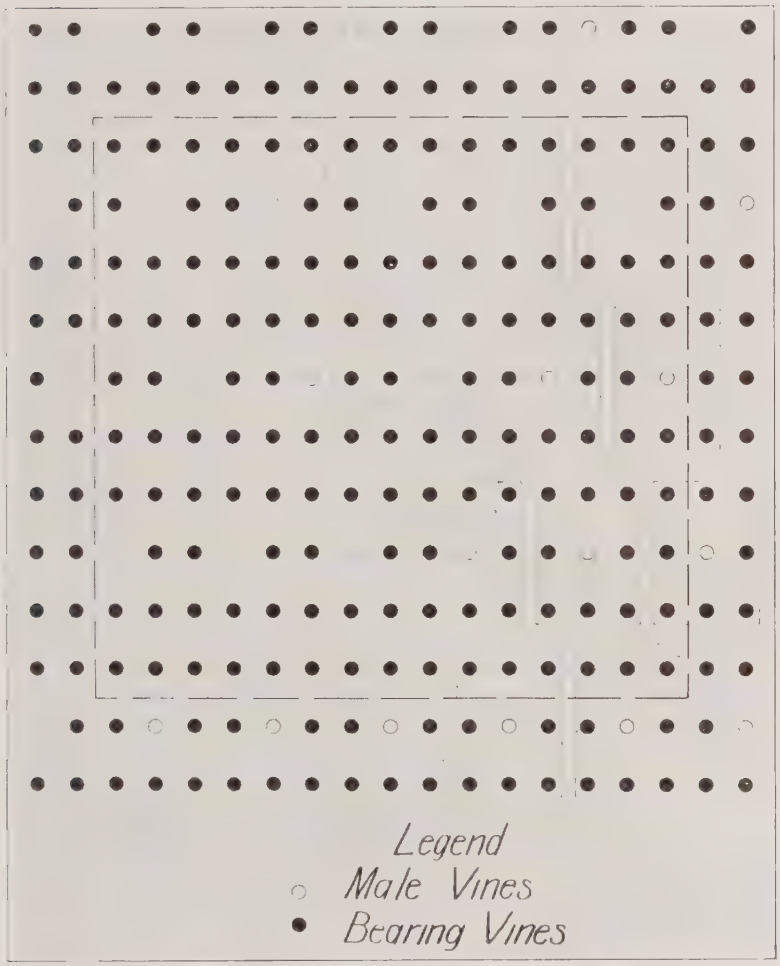

FIG. 4. *Vineyard planting plan showing a method of spacing male vines.*

line is the outline of an acre; the small rectangles contain a male vine and eight bearing vines. The male vines in the series of rectangles are staggered so that every row contains a male vine. This is a modification of setting a male vine "every third vine every third row." The fine, dotted lines outside of the acre plot indicate how the male vines are located if a larger planting is made or if it is extended later.

When large plantings are made, space should be left every 210 or 420 feet for roadways running perpendicular to the trellises. This facilitates such ordinary vineyard operations as spraying, removal of prunings, and hauling of the grapes.

PROPAGATION

The most successful method of propagating muscadine grapes is by layering. Layering consists of placing in a small trench canes of the current season's growth that have had the leaves removed from the lower portions. The basal portion of the cane should be covered with soil to a depth of four to six inches with the tips of the canes left uncovered. This is best done in late June or early July. By November roots will have formed at practically all the covered nodes. The canes should be taken up during the early part of the dormant season. These are divided into ten-inch, rooted cuttings, set in the nursery row, and grown for one year. These two-year-old vines are then ready to set in the vineyard. Vines used for propagation purposes are not trained on a trellis but are heavily cut back each year with all the current season's growth layered as previously described.

CULTURAL PRACTICES

SETTING THE VINES. The nursery vines should be set in the vineyard during December or early January. If set at this time, the roots have a good chance of becoming established in the soil before the onset of hot weather. Previous to the time of setting, the land should be well prepared for planting. The fields should be plowed deeply. Oftentimes subsoiling the row in which the plants are to be set is time well spent. Such a practice increases the probability of rapid extension of the root system and quick establishment of the vines in the soil. It is very important to keep the vines from drying out when they are received from the nursery or at planting time. Muscadine vines are difficult to get started, and excessive drying out of the roots increases the loss of plants set in the vineyard. Keeping the vines well covered with wet burlap in the field at planting time is well worth the effort it requires. Holes should be dug to a depth of 18 inches with a diameter of 18 to 20 inches. Six or eight inches of top soil should be placed in the hole. Only such root pruning should be practiced as is necessary to remove broken roots. The vine itself should be pruned to a single vigorous stem. Place the vines with the roots radiating in all directions in the hole, and firm the soil around the roots with the foot to insure good contact between the roots and soil. This is a very important step in the planting procedure to get a high percentage of the plants to live. The vine should be set no deeper in the vineyard than it was set in the nursery row.

PLANTING DISTANCE. For commercial vineyards it is recommended that vines be spaced 21 feet apart in the rows with the rows 14 feet apart. This would require 150 vines to the acre. Closer spacing results in crowding of the vines within a very few years. This wide spacing of the rows permits easy cultivation, and by using a tractor brush pusher or a hay rake much

hand labor can be avoided in the removal of prunings from the vineyard.

THE TRELLIS. The old overhead method of arbor training is not very satisfactory for commercial vineyards. The difficulty of cultivating, spraying, pruning, and harvesting makes this method far less satisfactory than the vertical trellis (figure 5).

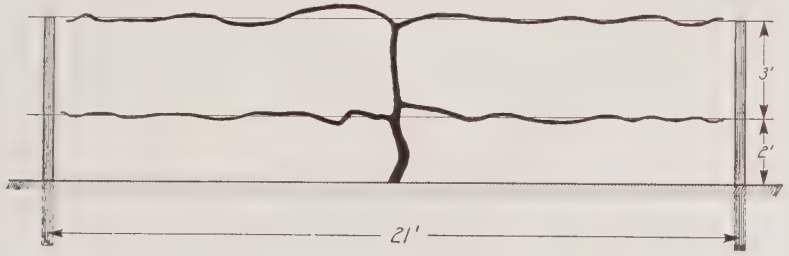

FIG. 5. *The dimensions of a two-wire trellis and the framework of vine. No lateral growth is shown.*

A trellis is erected for each row of grapes, placing a seven-foot post midway between each two vines. The posts are placed two feet in the ground. The end posts should be eight feet in length, set three feet in the ground, and well braced since they bear an uneven load. Two strands of smooth, galvanized wire are used. Size No. 9 is preferable for the upper wire while No. 12 may be used for the lower wire. This arrangement is just as efficient and more economical than using No. 10 wire throughout. If practical, the upper wire should be run on top of the posts, and the lower wire stretched 2 or 2½ feet above the ground. When cost is not considered, posts six feet above the ground are probably better in some respects than the five-foot posts.

The trellis should be constructed in time to begin training the young vines during the first growing season (figure 6). If planted

FIG. 6. *Vine trained on trellis after one growing season in the vineyard.*

at the proper time in soils of average fertility, most varieties will make sufficient growth to warrant the erection of a trellis the first year.

TRAINING THE VINES. The purpose of training is to establish, as soon as possible, the framework of the vine. This consists of a

single main stem to the top wire with arms extending in both directions along the two wires from the main stem (figures 7 and 8).

There is nothing that causes more loss of time, labor, vines, and waste of land than the erroneous impression that muscadine vines will produce bumper crops indefinitely by planting in a haphazard manner, and forgetting them until the second or third year when the vines are draped as best they can be over an improvised trellis. The muscadine grape is long-lived in the section to which it is native, provided it receives reasonable handling and care the first three years.

FIG. 7. *Two-year-old, pruned vine.*

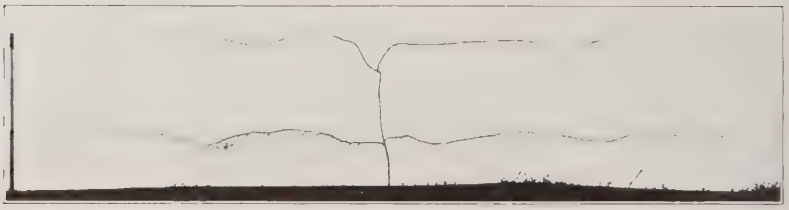

FIG. 8. *Vine shown in Fig. 7 beginning its third year.*

After growth starts the development of a main stem should be encouraged by pinching off the tips of side shoots so that the main stem may be forced to grow rapidly to the upper wire. Two side shoots that originate near the lower wire should be tied to and trained along the lower wire; these will form the lower arms. When the main stem has reached the upper wire, it should be trained along it in one direction and a side shoot should be permitted to grow in the other direction. By allowing but one main stem to grow and only the side shoots that form the arms to develop, it is possible to establish the framework the second year. When training, twining the arms about the wire should be avoided. Tying the arms to the wire with a loose loop of ordinary string will hold the arms in position until the tendrils have time to become attached to the wire and provide sufficient support. Twining the arms about the wire will eventually result in their

partial or complete girdling. Even when this does not occur it makes replacement of posts and wire difficult. Training after this consists of letting these four arms grow until they reach the post midway to the next vine. Each arm is cut back to this point at the annual, fall pruning. Thus each vine is limited to the trellis space between two posts, and this spread of the four arms is regarded as the permanent framework of the vines (figures 5 and 9). Three or four wire vertical trellises with arms on each wire are not recommended. With such a form of training, the shading effects are so great that only the top two arms give any sizable yield of fruit.

PRUNING. After the framework, consisting of a trunk and four arms, has been established, the vine is pruned annually, cutting the current year's growth to two or three buds. Small, weak, or over-vigorous canes are removed from the vines since it is the medium-sized canes that are most productive. The pruning cuts should be made close to the main arms in order to prevent an accumulation of non-bearing wood. Figure 9 shows the short

FIG. 9. *Ten-year-old Hunt vine pruned to short spur method.*

spur method which has been used with much success in pruning experiments at this Station.

Pruning must be done in the late fall and early winter soon after the first frost. If pruning is done much in advance of frost, the vine may be injured by "sunscald," and it is deprived of the ever-important, food-producing foliage. If the pruning is delayed until after the early part of December, the cut ends of the vines will bleed. Although the liquid given off in bleeding contains but a small amount of sugar, the volume is so great that the vines are weakened. One cannot over-emphasize the importance of pruning in this period following the first killing frost up to December 10-15. Later pruning, because of this "bleeding," is very detrimental to the vines.

If an arm dies, or for any reason needs to be replaced, this can be done by choosing the largest cane that has originated near the base of the dead arm and training it to the trellis wire from which the dead member has been removed. All tendrils that have become entwined around the arms should be removed when prun-

ing. These grow to be very tough and encircle the arms tightly, often girdling the arm and causing it to die beyond the point of injury as shown in figure 10. This unbalances the vine and necessitates the growing of a new arm.

FIG. 10. *Arm of muscadine vine girdled and killed by tendril.*

COVER CROPS. Cover crops turned under aid in providing the humus necessary for good physical condition of the soil. They increase the water-holding capacity, increase the absorption of rainfall, and also cut down on the amount of soil erosion. Rye

FIG. 11. *Cover crop of rye in young vineyard.*

and vetch mixed is a satisfactory winter cover crop for muscadine vineyards (figure 11).

This may be drilled in the centers between the rows of vines, taking care to leave the vine row free of the cover crop. Where diseases of Austrian Winter peas are not established, the peas make a satisfactory cover, though they are not nearly as efficient a cover as rye and vetch in controlling erosion. Where it is more important to prevent winter erosion than to add nitrogen to the soil, rye alone may be used as a cover crop. The rates of seeding per acre of the rye and vetch cover are 2 pecks of Abruzzi rye and about 15 pounds of either hairy or smooth vetch or rye alone at the rate of 3 pecks per acre. Austrian Winter peas are usually broadcast at the rate of 30-40 pounds per acre.

Winter cover crops should be plowed under about the middle of April or at such time as they have made their maximum growth before the soil becomes dry and hard.

Summer cover crops are generally not to be recommended for the muscadine vineyard. The roots of this grape are located very close to the surface of the soil and summer covers are injurious because of the severe competition for water and nutrients. Occasionally, where erosion is a problem in a vineyard, some sort of summer cover may be necessary. Using care in selecting the site for the vineyard will avoid this problem.

FERTILIZATION

Fertilization of muscadine grapes should be divided into two phases; that of fertilization of the young vines and fertilization of the bearing vines.

FERTILIZATION OF THE YOUNG VINES. The principal consideration during the first three years is to get as rapid growth as is possible so as to quickly get the vines to bearing size. Where manure is available, 10 to 30 tons may be applied per acre and thoroughly incorporated into the soil to insure maximum growth during these early years of the vineyard. Care should be taken not to get manure on the plants themselves or injury may result. If poultry manure is used, only about 1/3 to 1/2 as much is required. If manure is not available, chemical fertilizers should be used. A complete fertilizer such as 4-8-7, 5-7-5, or 6-6-6 (N.P.K.) is advisable. The first year the vines are in the vineyard, an application of 1/4 to 1/2 pound per vine of one of these complete fertilizers should be made about the middle of May and again about the last of July. The fertilizer should be kept a foot or more from the base of the vine. The second year the vines are set, the application should be increased from ½ to ¾ pound, depending upon the growth made. This application should be made immediately after the cover crop is turned under in April, with a similar additional application made the last of July. The third year the application should be increased to one pound with the time of application the same as given for the second year.

FERTILIZATION OF BEARING VINES. With bearing vines the main objective is to get a maximum production of fruit consistent with maintaining a vine of sufficient vigor to insure future crops. Fertilization after the third year is based not on any fixed practice but rather on the response of the vine itself. There is evidence that large amounts of nitrogen tend to produce too much vine growth accompanied by a decrease in yield. The nitrogen content of the fertilizer should be lowered to prevent the vines from making too rank growth if they seem over-vigorous, or it may be increased if they are lacking in vigor. Under conditions at Experiment, Georgia, a 6-6-6 (N.P.K.) fertilizer has given very good results. Generally, this fertilizer, or its equivalent, should be applied at the rate of 300 to 400 pounds per acre annually. By the time the vines come into bearing, the roots fairly well occupy the whole space in the vineyard, and broadcasting this fertilizer in the row middles seems to give fully as high yields as applying it in the area immediately around the vines. The fertilizer should be applied to the bearing vines in a split application following the cutting in of the winter cover, which usually takes place about the middle of April, with the second application the last of July.

HARVESTING

There is a tendency to harvest muscadine grapes before they reach full ripeness, particularly the dark-colored varieties. These dark varieties develop their color two or three weeks before reaching maturity, and this has resulted in harvesting green or nearly-ripe fruit, which appears to be ripe.. This has contributed heavily in creating and maintaining a preference for the lighter-colored varieties since the ripening of the latter is easily discernible. The average harvesting date given in table 1 is the time when the majority of the fruit of a variety has attained full ripeness and is ready to be consumed or processed. Since seasons vary considerably, probably the best test of maturity for each variety is to taste a few grapes before harvesting.

Hand picking is probably the most satisfactory method of harvesting muscadine grapes; its greatest disadvantage is its slightly higher cost for labor. This higher cost, though, is usually more than offset by decreased spoilage. The old method of shaking the vine and gathering the fruit on canvas sheets can only be done where the fruit is to be used within a few hours. This method of shaking is unsuited for fruit to be marketed for table use and not too satisfactory for fruit to be processed into wine and unfermented juice. Varieties which are to be used for table use or to be shipped should be picked in clusters by clipping the bunch with either a pair of grape shears or a sharp knife.

YIELDS. The average yield per acre of the Hunt variety of muscadine shows a range from three to nearly five tons per acre, dependent upon seasonal variations and the presence or absence

of diseases and insects. Although no records are available, from observation of its extreme productiveness it is assumed that the Creek variety would be even more productive. Yuga will probably rank with Hunt or possibly slightly below in production.

DISEASES OF MUSCADINE GRAPES

Among the diseases of muscadine grapes thus far fairly well known are black rot, angular leaf spot, Macrophoma soft rot, and bitter rot. Of these, angular leaf spot is a foliage disease, black rot attacks practically all the above-ground portions of the plant, while Macrophoma soft rot and bitter rot destroy the berries as they reach the ripening stage. No doubt additional diseases of equal or greater importance will be found on muscadines in the future, particularly should muscadine culture become more extensive.

MUSCADINE BLACK ROT, CAUSED BY GUIGNARDIA SP. This disease as it occurs on muscadines has probably been known for many years, but its etiology and the life cycle of the pathogen have been assumed to be identical with *Guignardia bidwellii* (E. & E.) V. & R., the organism which causes black rot of bunch grapes.

As stated above, practically all portions of the plant are subject to attack by muscadine black rot. The foliage symptoms are practically universally present on all the muscadine varieties. The lesions first appear as water-soaked areas of varying sizes on the young foliage, long before the individual leaves reach maturity. On closer inspection, the black fruiting bodies of the pathogen can be seen clustered in the developing lesion, and visible as small, black pimples on both surfaces of the lesion. As the young leaf continues to grow and approaches maturity, the lesions continue to develop and rapidly become brown to reddish-brown in color and angular to almost circular in shape (figure 12). At this stage the lesions are generally recognized as being typical of black rot. Long before the lesions have become highly colored, the pathogen discharges spores which bring about infections on other young leaves as well as on other portions of the plant.

In certain seasons favorable to the development of the disease, black rot attacks and causes destructive cankers on the current-year canes, the flower clusters, the fruiting pedicels, and the berries. This is particularly true of the better-quality varieties as Hunt, Yuga, and Creek. Cankers on the canes do not persist longer than the current season as they are usually excised by normal processes of growth of the canes during the second year. However, they do serve as important sources for spring infection as the pathogen continues to live through the winter in such cankers. As the berries approach maturity, particularly with the Hunt and Yuga varieties, cankers on the fruiting pedicels develop rapidly and tend to girdle them. Different varieties, and to some extent the individual vines of the same varieties, respond dif-

FIG. 12. *Typical lesions of muscadine black rot on an unnamed variety. A. Appearance of lesions on the upper leaf surface. B. Appearance of lesions on the lower leaf surface. Photographs natural size.*

ferently to the cankers on the pedicels. In some cases the berries hang on and shrivel, finally becoming hard and dry-like mummies, while in other instances the berries promptly fall off the vine, a condition known as "shelling." There has never been a complete crop failure at Experiment, Georgia, due to black rot, but in several years when pedicel cankers were numerous, the ground under the vines was covered by the fallen berries. Such conditions could reasonably represent a 10 to 50 per cent loss of marketable fruit. By comparison in a vineyard of bunch grapes, this loss would be excessive if not economically disastrous. Black rot rarely rots the entire berry. On some of the older varieties as the Scuppernong, about the only injury due to black rot is a scabby lesion. These lesions usually remain small in size and do not materially affect the quality of the berry. On such thin-skinned types as the Yuga, black rot causes deeper and more conspicuous lesions but rarely mummifies the berries. Other organisms, particularly those which cause soft rot and bitter rot, usually gain entrance through the black rot cankers and accomplish the complete destruction of the berry (figure 13).

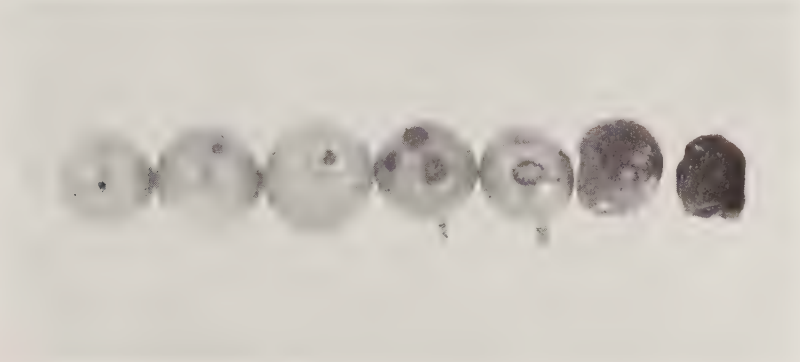

FIG. 13. *Black rot on Yuga berries. Beginning on the left, the berries show progressive rot up to berry No. 5. Beginning here, Macrophoma soft rot and Melanconium (bitter) rot have entered the black rot lesions and are completing the rot. Photograph natural size.*

When the infected berries and leaves drop from the vines in the fall, the black rot organism continues to live and grow over the winter season. During this period a special type of spore (ascospore) is produced and matured in the leaves. About the time the new leaves develop in the spring these spores are discharged by the pathogen in the old leaves lying on the soil under the vines. The spores become attached to the young leaves, and when the moisture and temperature relations are favorable, as they usually are in the early spring, the young leaves readily become infected. Likewise, the pathogen of black rot lives over winter and produces spores of the usual type (conidia) on other

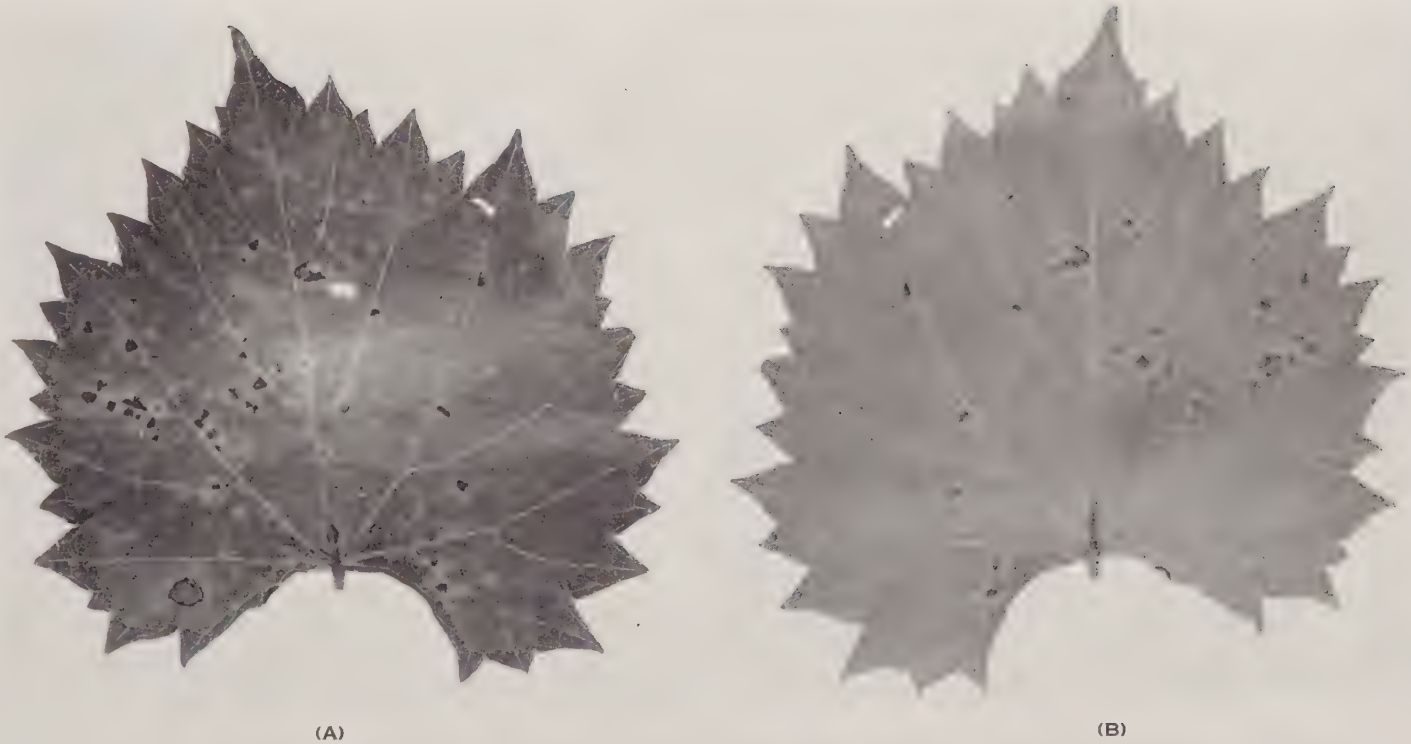

FIG. 14. *Typical lesions of muscadine angular leaf spot on muscadine leaves.* A. *upper leaf surface, and* B. *lower leaf surface of Hunt variety. Note the single lesion of muscadine black rot in the lower left and lower right, respectively, of A. and B. C-D. upper and lower leaf surfaces of male muscadine, showing severe spotting; older lesions. Photographs natural size.*

(C)

(D)

old, dead, or partly dead parts of the vines and berries, infected one-year-old canes, and fruiting pedicels.

The cause of black rot of muscadines. To those familiar with black rot of bunch grapes, the foregoing discussion of muscadine black rot brings several important similarities and differences to mind (15, 18, 23, 25). In the final analysis the black rot of bunch grapes, although it attacks the leaves, is predominantly a berry rot disease. It also causes cane cankers which continue to live for years. The life cycle and certain technical differences in spore size of *Guignardia bidwellii* differ significantly from those of the muscadine black rot organism. On these bases, as well as from a consideration of others not specifically mentioned, it appears that muscadine black rot is caused by a species of *Guignardia* different from the species occurring on bunch grapes.

Angular leaf spot of muscadines, caused by *Mycosphaerella angulata* Jenks. Angular leaf spot of muscadines is a foliage disease and insofar as is known never attacks any other portion of the plant. Its principal effect on the plant is accomplished through premature defoliation which might result in slow starvation or at least greatly weaken the vigor of the vines if not properly controlled. This in turn makes them particularly susceptible to other destructive maladies such as winter injury.

The symptoms of muscadine angular leaf spot appear first as small chlorotic areas on the leaf surface. Very soon the leaf tissue in the center of each chlorotic area dies and becomes brown to almost black in color, leaving a margin of colorless tissue, most evident on the upper leaf surface, which is called a halo (figure 14). As the individual lesions enlarge they tend to become angular in shape, due to the fact that they are somewhat delimited by the veins and the veinlets of the leaf. The halos tend to become less distinct as the lesions mature. In seasons of humid or wet weather the upper surface of each lesion, and, to a lesser extent, the lower surfaces, become covered with a gray to dark gray weft of mycelium which has somewhat the appearance of mildew. Under fairly dry conditions no weft is present but small pustule-like masses of gray to dark gray conidiophore fascicles may be seen on the lower surfaces of the lesions. Both the mildew-like wefts and the conidiophore fascicles are the summer fruiting stage of the pathogen. These bear numerous spores which are capable of infecting other leaves and thus contribute to the severity of the disease.

All the varieties of muscadines grown at this Station are susceptible to angular leaf spot, although certain of the older and less desirable varieties as Scuppernong, Flowers, and Thomas appear to suffer less damage than the later introductions of better quality. It would appear that a careful selection of parentage in a breeding program might result in strains of muscadines having both superior quality and resistance to angular leaf spot.

As in the case of muscadine black rot, angular leaf spot appears to be present in more or less destructive form wherever musca-

dines are grown. It is also apparent that bunch grapes are not susceptible to attack by muscadine angular leaf spot. This situation has been demonstrated through observations in vineyards in which muscadines and bunch grapes are growing more or less intertwined season after season. Under such conditions, the muscadines are consistently badly diseased by angular leaf spot, while the bunch grapes show no symptoms of the disease. The observation has been further confirmed by placing spores of the angular leaf spot pathogen on leaves of muscadines and bunch grapes under conditions that were favorable to infection. Only the muscadines became diseased with angular leaf spot. As in the case of muscadine black rot, when the leaves drop from the vines in the fall, the pathogen of angular leaf spot continues to live and develop over winter. In the early spring, as the muscadine leaves begin to bud, the pathogen begins to discharge spores which it has developed over winter in the old leaves on the ground and initiates new infections on the foliage.

Through a careful study of the pathogen throughout the season on field material and also in artificial culture in the laboratory, as well as by careful comparisons with similar pathogens which have been described from time to time on bunch grapes, it has recently been shown that the fungus causing angular leaf spot is a new species and has been named *Mycosphaerella angulata* Jenks (16, 17).

TWO SERIOUS BERRY ROTS OF MUSCADINES CAUSED BY *Macrophoma sp.* AND *Melanconium sp.* Aside from the berry rot initiated by the muscadine black rot pathogen mentioned earlier, two other destructive berry rots are now known to occur on muscadines as they approach the stage of ripening. One of these (figure 15) is caused by what appears to be a new species of Macrophoma. It has its counterpart on bunch grapes and is caused by a fungus closely related to *Macrophoma acniorum* Pass., the cause of Macrophoma soft rot of bunch grapes.

On muscadines the lesions begin as small discolored areas quite noticeable on the white or bronze-colored varieties at about the

FIG. 15. *Macrophoma soft rot on the Lucida variety. Photograph natural size.*

time the berries have reached their full size but usually before they have begun to ripen (figure 15). As the berries ripen the lesions grow larger and the berries are ultimately completely rotted. The final appearance of the berries is a soft rot, thickly covered by small, black pimples, the fruiting bodies of the pathogen. On most varieties the berries fall from the vines before the berry is completely rotted and become mummified on the ground. In other varieties the diseased berries cling to the vines and mummify there. Strictly speaking, the diseased berries merely become dehydrated, collapse, and in time shrivel to the extent that they resemble a mummy.

The pathogen causing Macrophoma soft rot has been found and isolated from overwintered, diseased berries, from old diseased pedicels that bore the diseased berries the preceding year, and from partly dead and dead one-year-old canes in the vineyard. It is strongly suspected that this pathogen may also possess another spore stage developed over winter as in the case of muscadine black rot and angular leaf spot. The chances are the perfect stage may be a Physalospora, closely related to *P. baccae* Cavara (*Guignardia baccae*) (*Cav.*) (*Jacz.*), a pathogen well known on the bunch grapes in Europe.

Melanconium rot or bitter rot of muscadine appears much like Macrophoma soft rot in its early stages, except that it never typically presents a soft rot stage. As a rule, the course of the development of the disease presents a typical dry rot and very early the berries show large areas of fairly large, powdery pustules, olive to almost black in color, completely or almost completely covering the berries (figure 16). The course of the rot from initial infection to complete rot is very rapid and the end result is a mummified fruit. Unlike the situation found in Macrophoma soft rot, the old berries are almost completely filled with stromatic mycelium so that the berry is a mummy in the true sense of the term.

The pathogen causing Melanconium rot or bitter rot has been

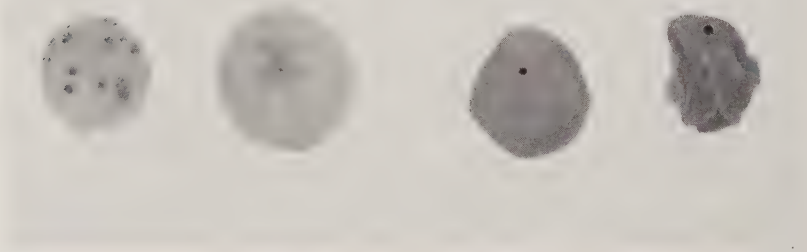

FIG. 16. *Melanconium (bitter) rot on an unnamed variety. Photograph natural size.*

isolated from mummied berries after these had over-wintered on the soil, from over-wintered, diseased pedicels, and from the bark of dead or partly dead one-year-old canes. It may be that this pathogen also develops an additional spore stage on diseased tissue over winter, but no such stage has as yet been found.

To what extent germinating spores of the pathogens causing soft rot and bitter rot are able to penetrate sound berries and bring about infection is not known. It is thought that they may often enter as secondary invaders following puncture injuries caused by the berries being blown against sharp projections on the vines or trellises, and from insect injuries, particularly the grape curculio. It is definitely known that both pathogens usually follow black rot injury and complete the rot initiated by this disease.

CONTROL MEASURES. From an earlier discussion of the several diseases under consideration it was shown that the casual organisms continue to live over the winter on the fallen leaves on the ground, and on other similar refuse from the vines; and that continued growth and development of the pathogens result in the formation of spores which mature in the early spring as the vines begin to put out new leaves. There is a critical stage in the pathogens here, particularly of black rot and angular leaf spot, in that all or most of the spores which were formed over winter are matured and discharged over a brief period of a few weeks. This situation is quite different from that found in black rot of bunch grapes in other sections of the country. Black rot of bunch grapes is known to discharge infective spores, produced over winter, all through the spring and summer, i.e., covering the entire growing season of the grapes (18, 23).

Thus, in order to control black rot of bunch grapes, one must continue to spray regularly throughout the growing season in order to keep a protective coat of spray on the leaves and berries, so that the infective spores which are being discharged following each rain may not bring about infection on the foliage and berries. This schedule is consequently a long one and is expensive (18).

In the case of muscadine black rot and angular leaf spot the early spring inoculum is soon exhausted, i.e., in three or four weeks, so that two to three sprays will essentially prevent initiation of a primary infection cycle. It is during this early period that control measures are most economically and effectively applied, because after the primary cycle of infection is initiated, new sources of infection are developed rapidly on the young foliage and canes, and the problem of control is almost immediately either entirely out of hand or else extremely difficult and expensive to apply effectively.

Results from spraying tests during the past few seasons indicate that all the diseases described above may be controlled from a practical standpoint by three applications of a 4-5-50 Bordeaux mixture spray, preferably preceded by a copper sulphate (4

pounds of bluestone to each 50 gallons of water) dormant spray. The schedule recommended here is only tentative and may be changed in detail as the tests are continued. The dormant spray may be applied at any time while the vines are dormant, but best results might be expected from the spray if it is applied three to four weeks before the buds begin to break in early spring. The first Bordeaux spray should be applied with a power sprayer at the time or shortly after the young leaves begin to emerge from the buds. It should not be delayed longer than the time when the young leaves are ½ to ¾ inch in size. The second Bordeaux spray should be applied from eight to ten days later, depending upon the rate of growth of the vines and the weather conditions. In other words, a serious effort should be made to keep the foliage covered during a period of three to four weeks; and it is essential that a good protective coat of spray be present on the foliage before the infective spores begin a fresh discharge following a rain. By watching the new growth and getting the second spray on just preceding a rain, very effective results can be obtained. The third spray should be applied about eight to ten days following the second, depending, of course, upon the weather conditions.

In addition to the sprays, strict vineyard sanitation should also be practiced. Knowing that the pathogens live over winter on vineyard refuse such as old leaves, dead and dying one-year-old canes, and diseased berries, one should effectively dispose of these materials early in the preceding fall. Many dangerous sources of infection as dead canes and clinging berry mummies can be removed by careful pruning. All this material should be burned or buried deeply since, if left on the vines or thrown on the soil and allowed to stay there, it may nullify control efforts the following spring. All old leaves should be raked from under the vines in the fall as soon as possible after the leaves have dropped and either burned or buried by deep plowing.

Although there is no experimental data on the amount of damage caused to muscadines by the grape curculio and other insects as the grape leaf moth, it is thought that during certain seasons these insects and others may destroy many berries. Likewise, they doubtless open avenues for the entrance of the two berry rots, Macrophoma soft rot and bitter rot. If there appear to be pests in the vineyard, lead arsenate may be added to the third Bordeaux spray. It may be that under certain unusual conditions a second arsenical spray may be necessary, but thus far there is no information on the subject.

Summary of suggested disease control measures:

1. Strict vineyard sanitation beginning in early fall and including careful pruning. All prunings should be burned. All leaves and fallen berries should be burned or raked into the middles and covered by deep plowing.
2. A dormant spray, 4 pounds of copper sulphate to each 50 gallons of water, should be applied when the vines are

dormant, preferably in early February.

3. Three Bordeaux mixture sprays (4-5-50) should be applied. The first should come as the young leaves are breaking the buds and not later than when the young leaves are ½ to ¾ inch in size. The second spray should come eight to ten days following the first and preceding a rain. The third should come about eight to ten days following the second. Every effort should be made to keep the young foliage covered with Bordeaux spray for three or four weeks, and particularly all foliage should be covered before a rain.

INSECT PESTS OF THE MUSCADINE GRAPE

In table 2 the most common insects attacking the muscadines in Georgia are given, listed in order of their appearance during

FIG. 17. *Injury due to feeding of the grape leafhopper.*

the season. As plantings become more extensive the insects will, no doubt, become more injurious and a regular control program will be necessary. As mentioned before, insecticides may be combined with sprays for disease control. These combination sprays are indicated in the table of insect pests.

Of the insects listed, the grape leafhopper, the grape flea

FIG. 18. *Larvae of the grape flea beetle and feeding injury.*

TABLE 2 INSECTS THAT INJURE MUSCADINE GRAPES IN GEORGIA

COMMON AND SCIENTIFIC NAME	DESCRIPTION	INJURY AND IMPORTANCE	CONTROL MEASURES
1. Apple twig borer *Schistoceros hamatus* (*F.*)	Blunt-headed, cylindrical beetle, 3/8 inch long.	Bore small holes in vines in late winter causing sap to run; occasional report.	Cut out dead wood on vines and nearby trees. Destroy all prunings of grape and fruit trees.
2. Grape flea beetle *Altica chalybea* Ill.	Blue jumping beetle 1/5 inch long. Dark slug-like worms (figure 18).	Beetles and worms eat holes in leaves in spring and summer; injury common but of minor importance.	Spray with calcium arsenate 2 pounds to 100 gallons of Bordeaux mixture.
3. Grape leafhopper *Erythroneura comes* (Say)	Streamlined, 1/8 inch long, yellow with dark bars or with brown network (figure 17).	Puncture leaves from under side and suck sap, making white specks throughout growing season. When thick, leaves turn brown and drop; injury common but usually not severe.	Clear out winter quarters in brush and grass. Bordeaux spray gives partial control. For severe infestation add nicotine sulphate 1 to 1,000 when young hoppers appear.
4. Grape leaf folder *Desmia funeralis* (Hbn.)	Wriggling caterpillar 3/4 inch long, green with black head, adult a brown moth with six white spots.	Caterpillars feed inside folded leaves in summer; rather common some years.	Crush worms in folds. Spray vines with arsenate when folds appear.
5. Grape rootworm *Fidia viticida* Walsh	Gray beetle, 1/4 inch, with broad shoulders. Fat worms on roots, 1/4 inch to 3/8 inch long.	Beetles eat chain-like holes in leaves in summer; worms destroy small roots; generally not serious.	Harrow last of May to kill young adults above roots. Spray with arsenical when leaf feeding is first seen.
6. Hog sphinx or hornworm *Darapsa myron* Cramer	Fat, big-headed worm 2 inches long with diagonal stripes, adult a green hawkmoth.	Eat large sections from leaves in summer; infrequent, though individuals conspicuous.	Hand picking or arsenicals.
7. Grape curculio *Craponius inaequalis* (Say)	Round, warty weevil 1/10 inch long. Grub pale and legless (figure 19).	Adults etch leaves; grubs burrow into fruits July to September; common.	Cultivate in summer to destroy soil burrows. Spray with arsenicals.
8. Grape root borer *Paranthrene polistiformis* (Harr.)	Fat worm 1–1 1/2 inches long, adult a wasp-like moth.	Make large burrows in larger roots and crown in winter and spring; vigor of vines decreased; occasional vine killed.	Dig out infested vines. Maintain vigor by proper culture.

FIG. 19. *Adults of the grape curculio.*

beetle, and the grape curculio are the most injurious. These are illustrated in figures 17, 18, and 19, respectively.

UTILIZATION OF MUSCADINE GRAPES

WINES. At the present time most of the crop produced in commercial muscadine vineyards is absorbed by the wine industry. The wine from these grapes has a characteristic flavor and bouquet, which causes it to be very much in demand by those who know it. Several large wineries located in Georgia and smaller local establishments are processing these grapes. How great a volume these plants will be able to handle and dispose of in the future is a matter of opinion. A recent development to extend the season in which these grapes may be processed is concerned with freezing the grapes solid in barrel lots and holding until such time as they may be conveniently utilized. Some processors have preference as to the varieties of grapes to be used for wine. Since the life of a vineyard ordinarily exceeds that of the man who plants it, special attention should be given to the preference of these companies to insure not getting a variety for which there will be no demand.

UNFERMENTED GRAPE JUICE. Unfermented, muscadine grape juice potentially offers great possibilities. This grape juice fresh from the press is a most pleasing and refreshing drink. Ordinary methods of pasteurization destroy the fine flavor of the fresh juice and impart to it a flavor which borders on the disagreeable. Until some method of processing is found which will retain the original and prevent the development of insipid, disagreeable flavors, commercial muscadine juice may be said to have potential, but

as yet not actual, possibilities. Much work has been done on this problem, but up to the present time we do not have the final solution.

There are two methods which have some value for storage of unfermented juice and maintaining its fresh flavor, but because of certain disadvantages are of but little commercial importance. The storage of bottled, expressed, unpasteurized juice under refrigeration at 32° F. retained the fresh juice for well over six months. After that time fermentation began to take place. Obviously, since the time of storage is so short, this would be of no great commercial importance.

Still another method of storage is to freeze the juice solid. Where facilities permit, this is a relatively simple method and the resulting product is good. The natural or blended juices are poured into containers and placed in a room at 0° F., or lower, to freeze. Frozen muscadine juice should be kept at 0° F. until a few hours before using. While this method preserves the juices in good condition, it is quite cumbersome to use since it requires considerable time to thaw.

FRESH FRUIT. Muscadine grapes eaten fresh soon after picking are excellent. With the development of varieties which have larger bunches and on which the berries adhere strongly, there will be an opportunity of marketing these as dessert grapes, especially in the South. The main objection to the older varieties of these grapes is that they rapidly deteriorate due to the exudation of juice over the grapes from the broken skin at the point of attachment with the pedicel. This makes the grapes sticky, dirty, and unsightly. It is for this reason that one of the main objectives of the muscadine grape breeding program has been to secure varieties in which the berries are persistent. Steady progress toward this goal has been made as evidenced by the variety Yuga, which not only has high quality and a large-sized bunch, but has berries which are persistent. As dessert grapes to be shipped to northern markets, the muscadines do not offer very great possibilities. They are not well known on the northern markets, and they would have to face very strong competition of the bunch grapes of the northern states which are in season at practically the same time. It is the South which offers the best fresh fruit market for these grapes.

JELLIES. Very good jellies and other forms of preserves may be made from muscadine grapes. For two consecutive years at this Station over 40 varieties of the muscadine grape were investigated for the purpose of determining any possible differences in the factors requisite for jelly making. The grapes tested ranged from the older and well-known types to the unnamed groups in the breeding vineyard.

Firm, fully ripe, but not over-ripe grapes were picked and delivered to the laboratory the day they were harvested. After sorting and washing, the fruit was weighed, mashed, and heated without added water. When the grapes had come to a full boil

they were cooked for eight minutes. The cooked grapes were first strained by squeezing through cheesecloth and then allowed to drip through a cotton flannel bag. The clear juice was tested for its pectin content. Approximately 1½ cups of juice and the indicated amount of sugar were weighed, cooked rapidly, and when done poured into hot, sterilized glasses. Jelly is done when it sheets or spreads out from a spoon, reaches a temperature of 210°-221° F., or cooks to a given weight.

Since the proportion of sugar (4, 5) to be used is dependent upon the pectin present in the extracted juice to make a standard jelly, it is essential to determine the pectin content of the juice. In this experiment the Jelmeter (figure 20) was used for the determination. It is a handy and convenient household gadget so designed that the amount of sugar to be added to one cup of juice is read directly.

The Jelmeter test indicated that the pectin content of the numerous muscadines varied widely, resulting in differences of over 300 per cent in the amount of sugar per cup of juice. The pectin content of several varieties was so high it was necessary to add water to the grapes during extraction. The same variety of grape in several instances differed sufficiently in pectin content in the two years to be significant. When the jellies were judged for consistency by the clean cleavage test, no difference was noted in any of them and all met the requirements of a standard jelly. This indicated that the pectin-sugar ratio had been correctly determined.

Of the most outstanding varieties from a horticultural standpoint, the pectin content was least in Creek and then increased in amounts in Yuga, Dawn, Dulcet, Brownie, Thomas, Stuckey, Sanmonta, November, and Hunt, with the most in Scuppernong. The amount of sugar used per unit of juice was nearly three times as much for Scuppernong as for Creek.

The color of the grapes and the resulting jellies were from light to very dark. Attractive, light jellies which ranged from deep tones of amber-white to bronze-yellow were made from Stuckey, November, Brownie, Scuppernong, Dawn, and Yuga, while popular dark ones were represented by the currant-red of Thomas and Sanmonta or the purplish-red of Hunt, Dulcet, and Creek.

Tartrate crystals often form in grape jelly which has been stored for several months. These deposits in the jelly can be eliminated, or at least reduced, by letting the extracted juice stand for 24-48 hours and straining off the tartrate crystals.

Muscadine grapes are excellent for jelly. In order to make a standard product, it is essential, however, that the pectin content be determined in order that the proper pectin-sugar ratio be maintained. If this ratio is not established, a syrupy jelly, due to additions of too much sugar or a tough jelly due to too little, is more apt to occur than one which meets the standard requirements.

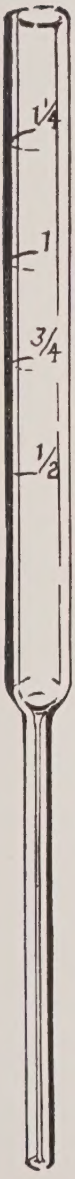

FIG. 20. *Jelmeter. The figures on the Jelmeter indicate quantity of sugar to add to one cup of fruit juice. This apparatus was developed by the Delaware Agricultural Experiment Station.*

REFERENCES CITED

1. Alwood, W. B., B. J. Hartman, J. R. Eoff, M. J. Ingle, and S. F. Sherwood. Development of sugar and acid in grapes. U.S.D.A. Bul. 335. 1916.
2. Anderson, R. J. Concerning the anthocyans in Norton and Concord grapes. A contribution to the chemistry of grape pigments. Jour. Biol. Chem. *57:* 795-813. 1923.
3. Armstrong, W. D., T. A. Pickett, and M. M. Murphy, Jr. Muscadine grapes. Culture, varieties, and some properties of juices. Georgia Agr. Exp. Sta. Bul. 185. 1934.
4. Baker, G. L. Improved methods of jelly manufacture. Food manufacture. 1934.
5. Baker, G. L. How much sugar in fruit juices. Food Industries *7:* 170. 1935.
6. Brown, W. L. The anthocyanin pigment of the Hunt muscadine grape. Jour. Amer. Chem. Soc. *62:* 2808-2810. 1940.
7. Brown, W. L. Unpublished results.
8. Caldwell, J. S. Some effects of seasonal conditions upon the chemical composition of American grape juices. Jour. Agr. Res. *30:* 1133-1176. 1925.
9. Dearing, Charles. Muscadine grapes. U.S.D.A. Farmers Bul. 1785. 1938.
10. Detjen, L. R. Pollination of the rotundifolia grapes. Elisha Mitchell Sci. Soc. Jour. *33:* 1917.
11. Dorsey, M. J. Pollen development in the grape with special reference to sterility. Minnesota Agr. Exp. Sta. Bul. 144. 1914.
12. Gray, Asa. Gray's new manual of botany. 7th edition. 1908.
13. Hartmann, B. G., and F. Hillig. Determination of citric acid in fruits and fruit products. Jour. A.O.A.C. *11:* 257-266. 1928.
14. Heiduschka, A., and C. Pyriki. Citric acid content of grapes at various degrees of ripeness and the determination of citric acid. Z. Unters. Lebensm. *58:* 378-381. 1929.
15. Jaczewski, A. Uber die Pilze welche die Krankheit der weinreben. "Blackrot" verursachen. Zeitschr. fur Pflanzenkrh. *10:* 257-267. 1900.
16. Jenkins, W. A. Angular leaf spot of muscadine grapes, caused by *Mycosphaerella angulata n. sp.* Phytopathology (in press).
17. Jenkins, W. A. Unpublished notes.
18. Loucks, K. W. Spraying experiments for the control of certain grape diseases. Florida Agr. Exp. Sta. Bul. 294. 1936.
19. Murphy, M. M., Jr., T. A. Pickett, and F. F. Cowart. Muscadine grapes. Culture, varieties, and some properties of juices. Georgia Agr. Exp. Sta. Bul. 199. 1938.

20. Nelson, E. K. The non-volatile acids of the strawberry, the pineapple, the raspberry, and the Concord grape. Jour. Am. Chem. Soc. *47*: 1177-1179. 1925.

21. Pickett, T. A. A note on muscadine grape seed oil. Oil and Soap *17*: 246. 1940.

22. Rabak, F. Grape seed oil. Ind. Eng. Chem. *13*: 919. 1921.

23. Reddick, Donald. The black rot disease of grapes. New York (Cornell) Agr. Exp. Sta. Bul. 293. 1911.

24. Reimer, F. C. and L. R. Detjen. Self-sterility ofthe Scuppernong and other muscadine grapes. North Carolina Agr. Exp. Sta. Bul. 209. 1910.

25. Rhodes, A. S. Diseases of grapes in Florida. Florida Agr. Exp. Sta. Bul. 178. 1926.

26. Small, John. Flora of the southeastern United States. 2nd edition. 1913.

27. Stuckey, H. P. Work with Vitis rotundifolia. Georgia Agr. Exp. Sta. Bul. 133. 1919.

28. Williams, C. F. Hybridization of Vitis rotundifolia. Inheritance of anatomical stem characters. North Carolina Agr. Exp. Sta. Tech. Bul. 23. 1923.

29. Wilstatter, R. and E. H. Zollinger. Coloring matter of the grape and the whortleberry. Ann. Chem. *408*: 83-109. 1915.

30. Wilstatter, R. and E. H. Zollinger. Anthocyanins of the grape and the bilberry II. Am. Chem. *412*: 195-216. 1917.